OGP Progress Report

Title of Abstract: Improved Water Demand Forecasting for Water Resources Managers
Project Duration: 5/1/03-4/30/06
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Introduction and Background

Water resources in the Middle Rio Grande River Basin are increasing in demand for such diverse uses as agriculture, municipal and industrial, maintaining healthy habitats for endangered species, and recreation. Because of competing water demands, there is a critical need for rapid improvement in calculating and forecasting daily agricultural and riparian water consumptive use demands. Evapotranspiration (ET) from irrigated crops and riparian vegetation, and evaporation from open-water surfaces are the primary consumers of surface water in the basin.

To address these problems, the U.S. Bureau of Reclamation (Reclamation) has developed and implemented the Agricultural WAter Resources Decision Support (AWARDS) system which is now operational in portions of Oklahoma, Oregon, Washington, Montana, Arizona, and New Mexico (Hartzell et al., 2000). The AWARDS system is an automated information system to assist water managers and users by providing easy access to rainfall and daily crop water use estimates. These estimates are based on real-time data obtained from the WSR-88D (Weather Surveillance Radar – 1988 Doppler) radar system and automated weather stations. Building on the AWARDS system, Reclamation has been developing an Evapotranspiration Toolbox (ET Toolbox) which adds GIS land use to specify crop, riparian, and open water surface acreage, as well as the vegetation type and coverage within selected Hydrologic Rainfall Analysis Project (HRAP) grid cells (Hartzell et al., 2002). The ET Toolbox estimates the daily surface water use requirements at a resolution useful for implementation in Upper Rio Grande Water Operations Model (URGWOM). Also, weather forecast fields from the National Centers for Environmental Prediction (NCEP) Eta model at the 12-km grid resolution are used to improve the ET Toolbox's 24-hr, 48-hr, and 72-hr forecasts.

The NASA Goddard Space Flight Center team has been developing a North American Land Data Assimilation System (NLDAS), which is characterized as a real-time, hourly, distributed, uncoupled, land-surface simulation system on a U.S. national domain at 0.125 (1/8) degree resolution. NLDAS has been a multi-institutional project and has a variety of physically-based, land-surface models (LSMs) implemented in the system. For this study, the LSMs include Mosaic (Koster and Suarez, 1996), Noah (Mitchell et al., 2000b), and the Community Land Model, version 2 (CLM2; Dai et al., 2002). The model forcing used to drive the LSMs is from NCEP's **E**ta-based 4-D **D**ata **A**ssimilation **S**ystem (EDAS) analyses and Eta forecasts. Some observation fields are used to replace the model forcing and include shortwave and longwave radiation-derived products from GOES and a merged product of "Stage IV" WSR-88D, gage precipitation, and EDAS total precipitation. Recently, NLDAS has been enhanced through the incorporation of the Land Information Systems (LIS) modeling framework, and it has allowed NLDAS to be run at the 1 km resolution and soon to be less than 1 km level.

Project Goals

The main goal of this project is to apply NLDAS and remotely sensed products, like those of the MOderate Resolution Imaging Spectroradiometer (MODIS), aboard the EOS Terra and Aqua satellites, to water resources management decision support tools and moels. Our aim is to improve our understanding of their contributions to the daily-weekly predictability of evapotranspiration (ET) of different vegetation types, open water evaporation, and bare soil conditions. NLDAS output will be compared and incorporated in to the Reclamation-developed ET Toolbox for the Middle Rio Grande area and evaluated with and without the new products. Water demand forecasting as addressed in this project is limited to the water demands from irrigated agriculture, riparian vegetation, and evaporation from open water surfaces. The study area includes the Middle Rio Grande in New Mexico from just above Cochiti Reservoir southward to Elephant Butte Dam.

For this collaboration, two main questions were established to carryout the needed research. The first question addresses the resolution (spatial and temporal) of vegetation indexing needed for this decision support system (DSS) used for water resource operational decision making and planning. One of the greatest needs for improving water consumptive use estimates and forecasts is the frequent updating of irrigated crop and riparian vegetation indexing. The second question is addressed with regard to how can estimated soil moisture fields from LSMs and field observations be used to improve the efficiency of water management. Currently, Reclamation uses surface water (open water surface areas and WSR-88D rainfall estimates using the 4-km HRAP grid), weather station data, and Eta model 12-km gridded data to calculate current and forecast daily ET amounts. Estimates of soil moisture in the root zone would be useful, and one of the project's goals is to show how it should help improve ET estimates. In addition, different MODIS products, like land surface temperature, will be assimilated into the LSMs to help improve their ET estimates and the effect on soil moisture estimates.

Method

Some of the underlying approaches for this project involve validating and benchmarking the ET of different LSMs and associated variables, parameters, and forcing which are used to calculate the ET with the current AWARDS ET-Toolbox decision support system (DSS). MODIS vegetation parameters and land cover/use products will be used to characterize the larger domain vegetation changes, and other MODIS land products, like land surface temperature, will be assimilated to update and enhance some of these LSMs ET calculations. To customize the NLDAS to more appropriately represent the Rio Grande basin region, the NLDAS-LIS based modeling system will be modified by employing the highest resolution information available (e.g., soils data, land class parameters, etc.) and assimilating MODIS products at 1-km and sub 1-km resolutions. Current aspects of the AWARDS ET-Toolbox DSS, like the real-time data from WSR-88D radar and automated weather stations and the land cover information pertaining to the Land-Use Trend Analysis dataset, will be incorporated in to the modified NLDAS-LIS modeling framework.

For the validation studies, observations from a growing network of meteorological stations in and around the basin will be used for comparison with the model forcing and state variables. In addition, other instruments like soil moisture and temperature proves will be included at select sites for more point-based evaluations of the models' performance.

Results and Accomplishments

Work Accomplished in Year 1 of this investigation:

- Set up ftp transfer ability of retrospective Mosaic and Noah LSM runs for Reclamation for years 1997-2003 and 2001-2003, respectively, for the two models. Also near real-time and forecast Mosaic LSM runs were made available as well.
- Developed transformations for NLDAS grid to ET Toolbox Grid and integrated case study examples of NLDAS 12 km data into the ET Toolbox web page
- Compared NLDAS land surface model runs (Mosaic, Noah, and CLM2) to Reclamation's existing in-situ and operational data (static and time-varying) – initial validation phase and benchmarking:
  - ♣ Compared 8 of the meteorological stations so far with Mosaic and Noah LSMs for 2001-2002, and now working on CLM2 simulations
  - ♣ Comparing land use/cover (e.g., vegetation, soil) parameters and characteristics between NLDAS and datasets used in AWARDS ET-Toolbox
- Began migration to run LSMs on to 1 km with the NLDAS-LIS code, no tiling involved
  - ♣ NLDAS-LIS uses the 1-km based UMD vegetation classifications currently
- Began setting up the LUTA information to be used as sub-1km gridbox in the NLDAS-LIS modeling system
- Worked on identifying optimal site location and initial needs and instruments for upcoming Summer 2004 field work for certain stations
- Assessment of CLM2 's water and energy states (in particular soil moisture, soil temperature and radiometric fluxes) sensitivity to vegetation related input parameters such as land cover classification, Leaf Area Index (LAI) and Plant Functional Types (TFP), and soil physical properties (in progress).
- Validation of CLM2 parameterization for skin temperature against ground measurements and satellite derived land surface temperature (in progress).
- Presented initial results of study at GAPP PIs meeting poster session in Seattle, WA July 2003
- Presented plan and results at USBR Watershed and River Systems Management Program spring and fall workshops with over 20 Reclamation, USGS, DRI, and other engineers and scientists.

Future Work

Work to be accomplished within the next year includes the following:

- Run selected LSMs for over Rio Grande area with 1 km MODIS-based classifications
  - ♣ Adjust forcing datasets for the 1-km runs, starting with the merged Stage IV/gage/Eta forecasted precipitation products, to be later aggregated to the the HRAP level for comparison
  - ♣ Begin using Reclamation's radar and gage-based higher resolution products in the modified NLDAS-LIS system

- Incorporate the much finer resolution parameter (e.g., soil classes) and land class/use information (e.g., the LUTA information) into NLDAS-LIS and treat this information as sub-grid heterogeneity (e.g., like "tiles") of the 1-km resolution grid system. Then the different LSMs will be run with these datasets and validated with the in-situ measurements (e.g., soil moisture and energy fluxes).
- Install new instruments at specific sites for more detailed model soil moisture and ET validation and benchmarking
- Identify and implement optimal land assimilation techniques for assimilating MODIS LST into the CLM2 model. Assess possible improvements in ET and soil moisture with a retrospective analysis, and a near-real time analysis (using the MODIS Rapid Response LST product; available within 2-3 hour satellite after overpass).

References:

Hartzell, C.L., L.A. Brower, R.W. Stodt, and S.P. Meyer, 2000: Agricultural Water Resources Decision Support System. *Preprints, 2nd Conference on Environmental Application*, Amer. Meteor. Soc., Long Beach, CA, pp. 98-105.

Hartzell, C.L., L.A. Brower, and S. Hansen, 2002: Agricultural Water Resources Decision Support System and Evapotranspiration Toolbox. *Preprints, 16th Conference on Hydrology*, Amer. Meteor. Soc., Orlando, FL, pp. J198-J203.

Publications from this project:

No peer-reviewed publications as of yet

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